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Specification as originally filed, with Application for Patent Serial No: 2,333,829, on  
February 5, 2001, by CATENA NETWORKS CANADA INC., assignee of Alberto Ginesi  
and Andrew Deczky, for "Method for Adapting the Receiver Demodulation Structure  
According to the Transmitter IFFT Size, in DMT-Based ADSL Modems".

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(CIPO 68)  
01-12-00

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## **ABSTRACT**

It is proposed to have the IFFT size information exchanged during the initialization of the modems. For a number of reasons different vendors may decide to generate the transmit signal (either the U/S or the D/S) through IFFT sizes greater than the ones specified by the Standard. Letting the receiver know the IFFT size of the transmitter can guarantee inter-performance between different pairs of modem. The receiver could in fact adapt its FFT size to match the IFFT size in the transmitter.

## Introduction

It is well known that some current G.992.1 and G.992.2 modems implement the transmitter (either the U/S or the D/S) with an IFFT size greater than the one specified by the Standard. There are many reasons behind this choice. In particular, for the U/S channel an IFFT greater than 64 points may be justified by mainly two reasons: i) HW symmetry with the D/S channel; ii) ease the implementation of the different Annexes of G.992.1 and G.992.2 with the same data path. Even though this does not compromise interoperability, if the receiver is not made aware of the IFFT size inter-performance may be affected, particularly on short loops.

In order to understand the issue, let us consider Figure 1, where a Standard-size IFFT transmitter is shown together with a double size IFFT transmitter.

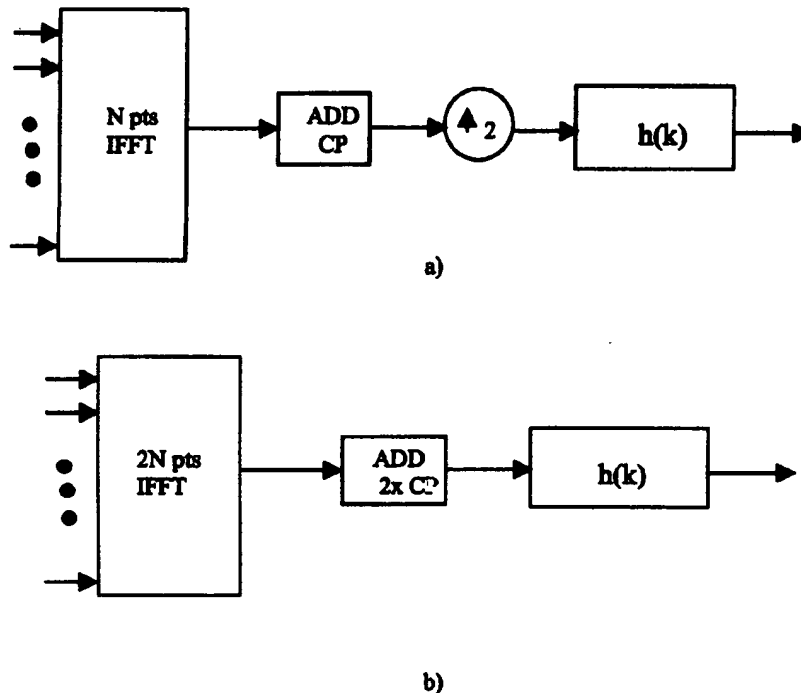


Figure 1: a) N-pts IFFT followed by CP insertion, upsampling by 2 and filtering by  $h(k)$   
 b) 2N-pts IFFT followed by 2xCP insertion, filtering by  $h(k)$

In Figure 1  $h(k)$  represents the channel and the transmit front end filters all merged into just one filter whose impulse response is sampled at a certain sampling frequency (twice the N-pts IFFT clock frequency). Scheme a) uses an N-point IFFT so, after adding the CP (Cyclic Prefix), an upsampling by 2 is needed to get to the channel sampling frequency. Scheme b) starts with a double size IFFT and it adds twice the number of samples for the Cyclic Prefix. While the two schemes generate the same identical signal while transmitting constant QAM symbols (REVERB-like DMT symbols), it is easily seen that the two generated signals are different in ShowTime mode.

Let us consider an example related to the U/S channel. In particular, let us assume that the channel is placed at 552 kHz sampling frequency and its frequency response and impulse response be the ones shown in Figure 2a) and 2b) respectively. In this example, the channel has been designed as a 6<sup>th</sup> order Chebyshev type 2 band-pass filter with 30 dB stop-band rejection. For the case of scheme a)  $N$  is 64 and CP is 4 samples. For the scheme b) the IFFT has 128 points and the Cyclic Prefix has 8 samples.

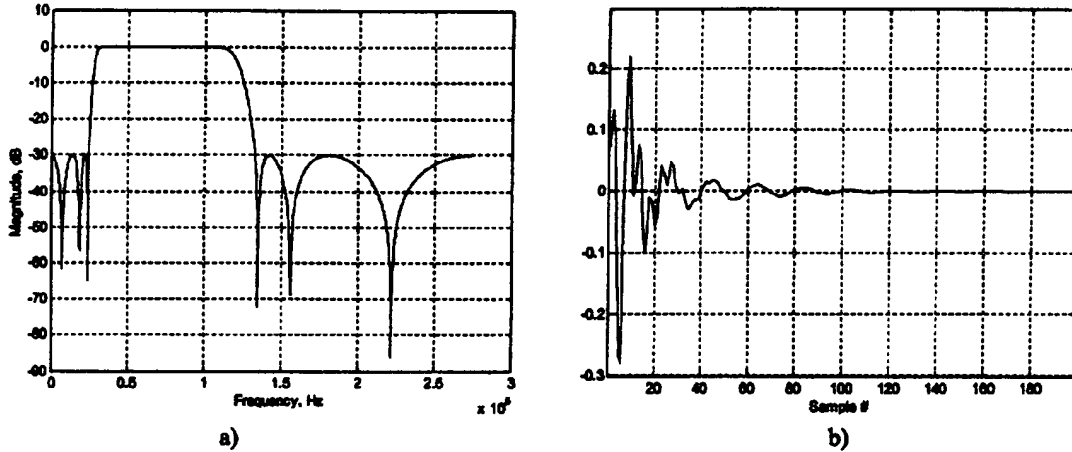


Figure 2: a) Amplitude frequency response of the filter  $h(k)$ . b) Impulse response  $h(k)$

For simplicity, let us also assume to transmit only one bin, say bin 12, and collect the output of the two schemes of Figure 1) when the following two QAM symbols are transmitted into two consecutive DMT symbols:  $1+j$ ,  $-1-j$ . Figure 3a) shows the output of the system of Figure 1a) while Figure 3b) shows the delta between the output signals of the two systems

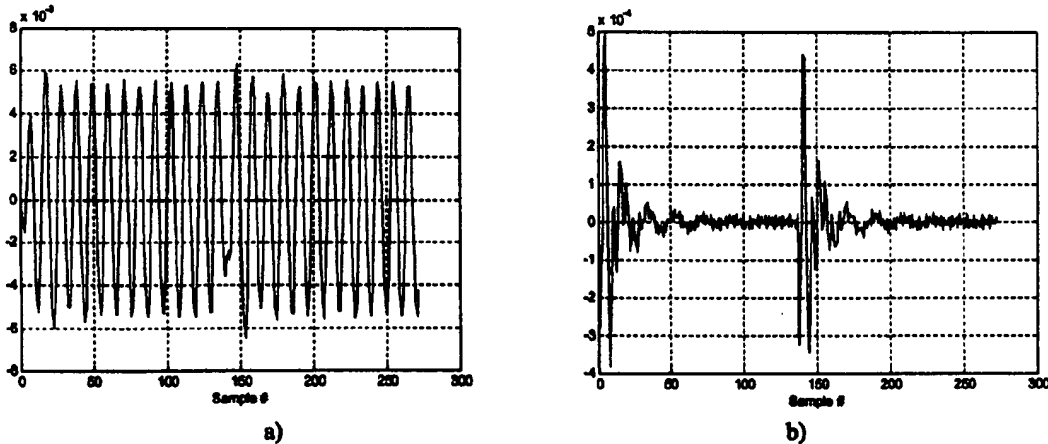


Figure 3: a) Signal at the output of the system of Figure 1a); b) Difference between the two signals at the output of the systems of Figure 1a) and 1b).

As shown, the difference between the two output signals is small and is concentrated around the CP regions. Figure 4) shows the frequency content of Figure 3a). It is clear from there that the error signal between the two systems of Figure 1) does not have only high frequency components (frequencies greater than 138kHz) as one might have thought by inspection of the systems of Figure 1.

Our lab tests show that if the receiver is not made aware of the IFFT size of the transmitter, on short loops data rate penalties of ~25-30% are experienced. Instead, if the receiver knows the IFFT size it can adapt its FFT size accordingly. This also involves changing the clock frequency of the Time Domain Equalizer (TDEQ) in the receiver.

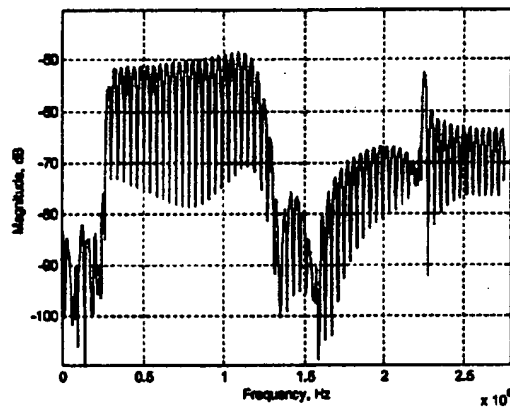


Figure 4: Spectrum of the signal of Figure 3b)

### **1. Claim**

We propose to have the IFFT size information exchanged between transmitter and the receiver during the modem initialization. This way the receiver can adapt its signal processing algorithms to adequately process the received signal, according to the transmitter IFFT size. In particular, the FFT size and clock can be matched to the IFFT size and clock. It is important that this information be exchanged well before the receiver equalizer is trained.

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